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CONCEPTUAL FRAMEWORK AND ASPECTS OF MULTI-PURPOSE PRODUCTION OF ENGINEERING AND AGRICULTURAL MACHINERY PRODUCTS: SOME PROPOSALS BY UNIDO *

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I. BACKGROUND AND JUSTIFICATION

1. The Second Consultation on the Agricultural Machinery Industry, held in Vienna (Austria) from 17 to 21 October 1983, proposed and discussed in depth the issue of the integrated manufacture of agricultural machinery and capital goods.[1/] One main conclusion was that "production of agricultural machinery should be considered as an integral part of national industrialization including the promotion of engineering and capital goods manufacturing programmes. It is therefore essential to develop programmes of product diversification and to introduce batch-level manufacturing. Combined production could be established in multi-product production plants with a view to accelerating the development of the engineering and capital goods sector including agricultural machinery."[2/]

2. The Consultation "recognized the validity and applicability of the concept of the multi-product production units for the manufacture of agricultural and capital goods equipment in developing countries. In areas where such units already exist, better capacity utilization is possible by adding new products, even if they are needed in other sectors, that suit the available production facilities. The exchange of information between the local partners, including Governments, should be strengthened."[3/]

3. The Consultation recommended the establishment, under the auspices of UNIDO, of a group of experts composed on the basis of equitable geographical distribution, taking into account the need for interested partners, including Governments, manufacturers and users of agricultural machinery, to be represented:

"(a) To carry out a precise assessment, on a selective basis, of the needs in terms of products and technology in purchasing countries, and of the industrial capacity available in supplying countries in terms of products, components and research and development. Based on this assessment, the expert

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1/ See issue paper II (ID/WG.400/5), 21 September 1983, background paper to issue paper II (ID/WG.400/6) and UNIDO working paper on the "Integrated manufacture of agricultural machinery and capital goods: Multi-purpose production routes".

2/ See Report (ID/307), para.54, page 17.

3/ Ibid., para.10, page 6.

group should work out particularly the details of the application of the multi-product approach and demonstrate practical ways of implementing this approach by establishing pilot multi-purpose plants, up-grading utilization of existing plants and adapting, as far as possible, techniques and products."4/

4. The meeting in Guangzhou is the first meeting of this group of experts recommended by the Second Consultation. Therefore, it was felt necessary that the concept of multi-purpose production should be discussed and clarified so that the long-term efforts to be developed will be based on a sound and clear philosophy. In fact, experience has shown the risk of distorting the concept in the following ways: it is neither new nor original; multi-product/purpose production exists and often dominates in many countries of the world, including developed countries; this approach is similar to product diversification and management of a product-mix. Experience has also shown that multi-purpose production appears in different forms: from the small rural workshop to the fully automatized flexible manufacturing workshop equipped with robots. The concept may also raise opposition, both of a theoretical nature, since it contradicts the law of economies of scale of specialized mass production, and of a practical nature, because of the difficulties of management and organization of production.

5. For these reasons, UNIDO considered it useful to include in the work programme of this meeting a discussion on the conceptual basis and rationale of the multi-purpose approach. This discussion should, however, be realistic: on the one hand, there is a need to find and define a "common line" among the various experiences so as to provide the multi-purpose approach with a certain identity and philosophy. On the other hand, it is necessary to relate theoretical hypotheses and/or concepts to practical experiences. Therefore, an "experimental research" approach should be followed during this Meeting, where concepts and experience are considered at the same time and are mutually supportive.

4/ See Report (ID/307), para.12 (a), page 6.

6. To t kle the conceptual aspects, UNIDO undertook research work, applying the methodology of Analysis of Technological Complexity (ATC), developed by UNIDO since 1979 in the field of capital goods, to the specific question of multi-purpose production.[5/] Because of the short time available and the various tasks to be performed during the Meeting, and also because of the very particular methodological content of ATC, it is not possible to discuss this work extensively during the Meeting. However, this paper intends to introduce some important aspects of ATC, in particular those related to the criteria of composition of multi-purpose plants (part III).

7. Before dealing with the technical rationale of multi-purpose plants, it seems useful to try to answer the basic question of "why multi-purpose production of agricultural machinery?". The multi-purpose production concept should correspond to a certain vision of manufacturing that ought to be reasserted.

II. THE UNIDO APPROACH TO THE MANUFACTURE OF AGRICULTURAL MACHINERY IN DEVELOPING COUNTRIES

8. Promoting the multi-purpose approach in the field of agricultural machinery has two basic aims/objectives:

- meeting the needs of farmers and rural development;
- forming a nucleus for the starting/strengthening of the industrialization process in developing countries.

9. As is clearly reflected in the first UNIDO World-Wide Study on Agricultural Machinery[6/] which was presented at the First Consultation on the Agricultural Machinery Industry, held in Stresa (Italy) in October 1979, UNIDO attempts to promote the idea and determine the characteristics of

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5/ Title of the study: "Essay on the multi-purpose production units. Theoretical considerations and practical applications." This work was carried out by Mr. Franco Vidossich (Brazil), author of the methodology, in co-operation with UNIDO, and currently project co-ordinator of a UNIDO project in Tunisia, using the ATC methodology for the development of the national engineering industries.

6/ UNIDO/ICIS.119.

alternative patterns of production of agricultural machinery, better adapted to the priority needs and conditions of developing countries. The following facts justify this effort for finding alternatives:

- Developing countries produce about 10 per cent of the world production of agricultural machinery, while representing more than 80 per cent of the world farming population;

- There are enormous needs for equipment for the agricultural and rural sectors in developing countries. These needs can be met only partially by the imports from developed countries[7] because the equipment ought to suit the variety and specificity of agricultural, climatic and social conditions. For example, 80 per cent of the farmers in the world cultivate an area of less than one hectare. It is therefore impossible for them to buy and rationally use conventional tractors. The food challenge in most developing countries calls for a drastic increase in the local capacities for designing, producing, maintaining and repairing the most important agricultural and rural equipment.

10. When manufacturing capacities exist, it is observed that in many countries they operate at a very low utilization rate and face many difficulties.[8] Although the prevailing agricultural crisis and the low price level of agricultural commodities definitively affect the purchasing power of farmers and decrease the market for agricultural machinery, this situation also witnesses the failure of specialized large plants designed for the mass production of one product. In fact, in many countries, especially those of a small or medium size, the needs of the farmers are wide in terms of variety, but small in terms of quantity. Multi-purpose agricultural machinery plants are desirable in order to meet the diversified requirements of farmers and related rural activities (storage, transport, etc.). The golden rule to be followed was expressed by Mr. Wang Wanjun, referring to the Chinese experience: "If the agricultural machinery plants want to get a foothold in the country and become flourishing, they must do whatever the farmers need."[9]

7/ These imports are drastically cut down because of the enormous foreign exchange problems that many developing countries are facing.

8/ See the study on Africa "Agricultural Machinery and Rural Equipment in Africa; a New Approach for a Growing Crisis" (UNIDO/IS.377).

9/ Wang Wanjun, "Establishment of a Multipurpose Agricultural Machinery Plant", paper prepared for UNIDO, 1984.

11. This approach is in line with two main principles developed by UNIDO in its previous work:

- The agricultural machinery sector is at the interface between agriculture and industry. Its success and development depend fundamentally on its ability to meet agricultural requirements. In this sector, industry should be at the service of agriculture. However, without a good national agricultural machinery sector, agricultural mechanization and food development are doomed to failure, because it will be impossible to increase sufficiently the productivity of land and rural manpower.

- Agricultural machinery should be considered in its wider sense and therefore include the various metal products and engineering equipment needed by all priority agricultural and rural activities (including irrigation, storage, food processing, construction, transportation).

12. The principle of meeting the diversified needs of farmers and related rural activities is full of significance and consequences. It expresses a "living" linkage between the plant/unit and the farming and rural world, in the following ways:

- multi-product production (because of the various needs), or multi-function, in particular the necessity/interest of having repair activities, manufacture of spare parts, sales and maintenance of equipment in use in the region in the same unit;

- necessary knowledge and "follow-up" of the needs, to be translated in appropriate designs, prototypes and models of products, and involving a certain "feeling" and capability of the entrepreneur to adapt and satisfy the market requirements;

- importance given to the after-sales service, training of the users for the operation and maintenance of the equipment;

- adaptation to the variable character of this demand (seasonal variation of the needs, dependence on contingent factors like climate, purchasing power of farmers, role of co-operation and parastatal organizations in the choice and supply of agricultural machinery);

- full integration (physical, human) in the rural milieu in terms of resources (local manpower), and constraints (transport infrastructure, supply of raw materials, energy, industrial supportive activities, training, banking, etc.).

13. Another function to be fulfilled by a multi-purpose unit is its role in the introduction or strengthening of a more self-reliant and indigenous industrial development. In fact, countries which are less industrialized and have low national incomes are those where the need for a vigorous development of national manufacture of agricultural machinery is of crucial importance in order to meet the requirements of farm mechanization, food production and rural development. This shows that the agricultural machinery sector has a key function to play as a nucleus and catalyst of industrialization in an unfavourable environment. How can this objective be achieved?

14. Firstly, as recommended by the Second Consultation, the integrated manufacture of agricultural machinery and capital goods (engineering products) should be considered. Secondly, it has been observed that specialized units can rarely fulfil such basic functions in the process of industrialization in countries at early stages of this process. Sometimes such units are a "caricature" of industry, performing only final assembly without enabling the increase of local/national industrial integration, the accumulation of technical knowledge, and without attaining a minimum of profitability.

15. Multi-purpose agricultural machinery plants (MPAMPs), while meeting the various priority needs for engineering products of agricultural and rural sectors, should contribute to the process of industrialization through the use of local resources and manpower, the acquisition and mastery of efficient and adapted technology.

16. The multi-purpose approach corresponds to the search for a possible new combination of technological potentialities and resources (primarily from the country itself), which are mainly manpower and equipment, into efficient systems of production/manufacturing units, capable of meeting the two fundamental objectives stated above. Because of the variety of countries, situations, needs and objectives, it is clear that there is no standard multi-purpose agricultural machinery plant. There are and there will be different types of multi-purpose agricultural machinery plants, characterized by various sizes, levels and types of technology, social nature, etc.; this will be evidenced by the experiences and papers to be presented at this Meeting. However, all multi-purpose agricultural machinery plants have or should have a common technical rationale that ought to be clearly identified.

III. A PROPOSAL FOR THE CONCEPTUAL FRAMEWORK OF MULTI-PURPOSE PRODUCTION[10/]

Introduction

17. As already mentioned, the existence of too many techno-economic limitations obstructing the creation of engineering industries or preventing their development in many developing countries justifies the search for alternatives. A structural formula capable of dynamizing the activity of engineering industries of developing countries could be that of multi-purpose production units. They should replace the large production runs of specialized companies (which are almost always incompatible with the markets of developing countries) by production in smaller batches of a certain variety of specific products. All the same, these units must operate with "critical masses" of sufficient size to ensure that a minimum of industrial significance (economic and technological) is retained in this structural change.

18. The production of finished and intermediate engineering goods and components in the engineering industries of developing countries will therefore be achieved either by imitating specialized production units in the industrialized countries, accompanied by the greatest possible reduction in size, or by multi-purpose enterprises that have replaced series production by the manufacture of a range of types, models and special products.

19. This approach is attractive, particularly as it seems to be difficult to envisage other valid structural alternatives. However, if multi-purpose units are to maximize their advantages for the developing countries and minimize their limitations and weak points, they must be designed and operated according to precise rules and in such a way as to keep control over their fields of action.

10/ This part is based on the research carried out on the basis of the methodology of Analysis of Technological Complexity, entitled "Essay on the Multi-Purpose Production Units", by F. Vidossich.

20. It will be readily recognized that the degree of flexibility of production incontestably increases as soon as one passes from a combination of series production and specialization towards multi-purpose units. A first objective for the developing countries would therefore already be achieved by making possible production activities that would otherwise be postponed indefinitely. However, in order to achieve another goal which the developing countries can by no means abandon, the multi-purpose units must be designed and operated in such a way that they can accumulate technological knowledge.

21. To guarantee this accumulation process, an endeavour should be made to establish industrial configurations capable of precisely defining the fields of action of the various types of multi-purpose units.

Criteria for the composition and structure of multi-purpose plants

22. With the aim of establishing practical and operational literature in the form of a guide for the developing countries for the design of multi-purpose units and on how they would operate, UNIDO proposes to consider the following series of patterns of multi-purpose units (MPUs).

23. When one analyses the production pattern of OECD countries, for example, one can see that some forms of multi-purpose production already exist. It should be ascertained whether they are applicable to the developing countries and if others can be envisaged.

24. It would be wrong to associate multi-purpose production with random production on the basic assumption that it is sufficient to have a certain stock of machine tools so varied that they can do almost anything. This interpretation is not adopted by UNIDO. It is, rather, desirable to observe and interpret what has already been done in certain developing countries during the last 30 to 40 years in order to decide on criteria for the composition of multi-purpose plants.

25. In order to be acceptable, the composition criteria of multi-purpose plants should be suitable for the production of agricultural machinery (including rural equipment) and capital goods in general. The point of departure is always versatility in small batches and an acceptable operational "critical mass" rather than a high degree of specialization or large production runs. All this should be carried out in such a way that the various products manufactured have some common dominant characteristics (homogeneous characteristics), which should not only refer to the nature of the production equipment.

26. Eleven types of multi-purpose units have been identified, belonging to three characteristic and well differentiated groups:

(a) MPUs whose common dominant and homogeneous element is the production equipment. Four different situations can be noted.

(b) MPUs that are homogeneous in terms of the ranking of well-defined factors. Three main cases can be identified.

(c) A variety of characteristic cases reflecting or belonging to four very different situations.

27. The "common" characteristics of multi-purpose units are as follows:

GROUP I - PRODUCTION EQUIPMENT AND PROCESSES

MPU 1 Metal forming machine tools

MPU 2 Chip removing machine tools

MPU 3 Metal forming and chip removing machine tools

MPP.4 Manufacturing processes

GROUP II - LEVEL OF SOME PRODUCTION FACTORS

MPU 5 Precision and/or quality

MPU 6 Homogeneity of H_d

MPU 7 Homogeneity H_s

GROUP III - MISCELLANEOUS

MPU 8 End-user sector

MPU 9 Common-user sectors

MPU 10 Hi-tech equipment

MPU 11 Repair and maintenance

Some examples for each multi-purpose unit:

MPU 1 Boiler-making without machining (except drilling) - metal structures - vehicle bodywork - simple one-piece components - stamping for third parties

MPU 2 Machines and components in general

MPU 3 Machines and components for engineering industries in general

MPU 4 Electrode position for third parties - various surface protection processes - heat treatment - stress relieving - painting

MPU 5 Measurement and control instruments - standard components for cold stamping and moulds for plastics

MPU 6 Machines, mechanisms, very wide variety of components

MPU 7 Furnaces (medium and high temperatures for a wide variety of uses) - equipment for food processing - equipment for food preservation

MPU 8 Equipment for making bread, rusks, etc. - equipment for service stations - equipment for hospitals

MPU 9 Components for hydraulic, pneumatic, lubrication, vacuum, electric and electronic circuits, optical and other elements

MPU 10 Products manufactured with advanced technology - satellites, telescopes, physical research instruments, rockets

MPU 11 Maintenance of electric motors, pumps, compressors, etc.

28. Figure 1 shows the eleven multi-purpose units selected as well as the most important interactions or linkages between them. That means that there must always be an outstanding dominant characteristic in each multi-purpose unit, but it does not mean that there may not be some degree of coincidence with other multi-purpose units among the remaining ten.

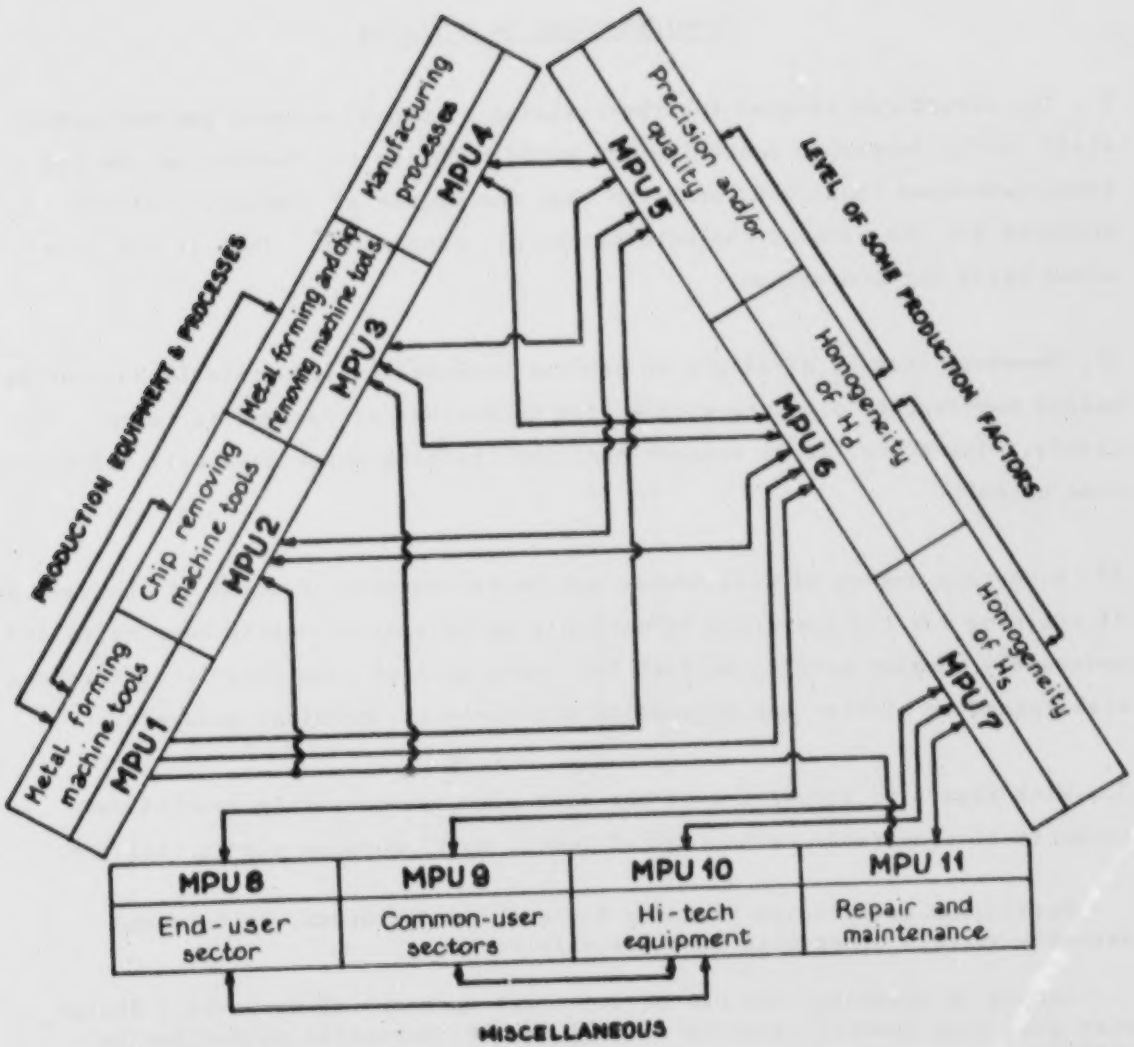

Figure 1: Interactions between the common dominant elements of MPUs

29. If multi-purpose plants are adequate for a lot of developing countries, the question arises whether their large-scale presence in the engineering industries would raise special problems that should be pointed out, particularly in relation to the skills and training requirements.

Considerations on training

30. The structures adopted for the training of manual workers and management staff in the developed countries are valid both for the developing and the least developed countries, provided that the degree of complexity of the products and the size of the enterprises are comparable. That is the only sound basis for comparison.

31. However, that is difficult to achieve because the industrialized countries mainly manufacture products with a high technological content in large plants. Therefore, it is evident that the training structures will differ to some extent.

32. A certain degree of coincidence may be encountered in terms of the variety of training for the operators of machines up to semi-automatic complexity and moderately complex setting skills, but there will be considerable differences with regard to middle- and especially higher-level technical managers.

33. With regard to industries of the same size manufacturing specialized products of comparable technological level, multi-purpose plants call for:

- Meticulous and precise training for machine operators, setters and assembly workers other than line assembly workers;

- Generally speaking, the use of universal machines of up-to-date design with good chip-removal capacity as well as semi-automatic production is sufficient in the vast majority of cases. Specialized machines, numerical control, and other advanced production equipment should always be considered as a secondary option, that is to say an attempt must always be made to redesign products and processes so that conventional machines can be used;

- The technical skills of the setters and fitters must, without doubt, be the highest possible but should always be consistent with the level of technological complexity of the product;

- Middle-level technical supervisors must receive training of the highest quality, always compatible with the technological level of the products. They will have to play a large part in bearing the technical pressure, comprehending and assimilating know-how in multi-purpose enterprises;

- As far as high-level supervisors are concerned, two aspects should be borne in mind. The purchase of know-how and work under licence reduce the scope of action and the contribution of design departments. This has an immediate effect on the corresponding training;

- Ad hoc training must be provided for the management of multi-purpose enterprises, i.e. it must be more intensive and given at an earlier stage than in the case of specialized enterprises of the same size. In fact, multi-purpose plants must operate with a variety of parts machined by third parties and with assembly activities that almost always correspond, in numerical terms, to those of larger specialized firms. In that case, training is required not only for the procurement manager and the production manager but also for the auxiliary technical staff;

- In any case, what was formerly very difficult to manage (it is sufficient to consider the examples of multi-purpose plants in Brazil and Argentina 20 years ago) is now much simpler with the use of micro- or minicomputers, and the difficulties and uncertainties of decision-making have almost disappeared. However, this change in the structure of management, which is incidentally not peculiar to multi-purpose plants, calls for specific training;

- As far as production management within the multi-purpose plants is concerned, it will be noted that it can develop between two structurally very different extremes. On the one hand, the manufacture of many products or articles consisting of only a few parts, and on the other hand, the manufacture of few types of products, each in two, three or five different models and each consisting of many parts.

Multi-purpose production, external know-how and standardization

34. Multi-purpose plants raise a problem with regard to the origin of licences, the purchase of designs and the choice of technical assistance. In order to maximize benefits, it is necessary to reduce the number of technical standards as well as the variety of materials as far as possible, choosing licenses with this in mind.

35. If absolutely necessary, all these licenses can be adapted to a single technical standard, but that takes time and a great deal of technical knowledge, which is often not available.

36. In order for multi-purpose plants to be efficient, it is necessary that there is not too much difference between the degree of technical complexity of the simplest and the most advanced products in the mix. That principle is in line with MPP.6 already described (compatible with the local technical level).

37. Study of an OECD product shows that sometimes its manufacturer needs a special machine or very costly tools. When no alternative exists with other, simpler production equipment, it is advisable systematically to:

- observe what is done with other products with the same function;
- try to redesign certain parts of the product, perhaps with the assistance of the licensor.

38. The same recommendation applies to products that depend on an infrastructure or industrial fabric that is too complex, or on technology that is too advanced (castings, forgings, technical services rendered by third parties).

Possible sizes of multi-purpose plants

39. The multi-purpose approach also raises the following questions: What is the best size, what are the minimum and maximum sizes that can be considered as valid, efficient and manageable in the developing countries and above all in less developed engineering industries? Information gathered from the developing countries clearly shows that the size of the unit must be in direct relation to the complexity of the product. On this point also, it would be important to gather the experience of those present in the Meeting, both in the field of agricultural machinery and other capital goods. The basic criteria for deciding on the size of multi-purpose plants must always be related to correct use of the local/regional industrial fabric, and assembly and semi-assembly activities should be avoided.

The dynamic character of multi-purpose plants

40. Finally, it is necessary to ask the following important question: Can multi-purpose plants guarantee the process of acquisition of technological knowledge or should they rather be regarded as a "passive" form of production, at least in the majority of cases?

41. Initially, multi-purpose plants lead to the accumulation of technical knowledge on production, management and maintenance among users. In-house capacity for product design is considerably diminished by the purchase of a large number of licenses. The purchase of product know-how postpones indefinitely the actual assimilation of know-how. This negative aspect can, to a large extent, be offset by the dynamic role that can be assigned to a wide variety of multi-purpose plants and for products of very widely differing complexity.

42. On the one hand, the multi-purpose plant should be considered as a development pole that in time hands over the manufacture of products or lines of products to new specialized plants. The increase of the markets and the technological mastery achieved, form the basis for this possiblity (see figure 2). On the other hand, it is necessary to offset the "releases" with an inflow of new products or lines of products, while respecting the composition rules indicated in figure 1. This dynamic process of release and inflow must be achieved, and that is possible with a systematic and progressive increase in the technological complexity of the products manufactured.

- Under these conditions and to the extent that they can be consistent with the rules of composition shown in figure 1, the multi-purpose units are transformed into genuine poles of development and as such are irreplaceable in the production context of the engineering industries of developing countries.

- The multi-purpose approach must under no circumstances be considered as a static and isolated solution. We therefore propose that the approach be always associated with a dynamic attitude such as that described above and with a definite pattern of composition (see figure 1).

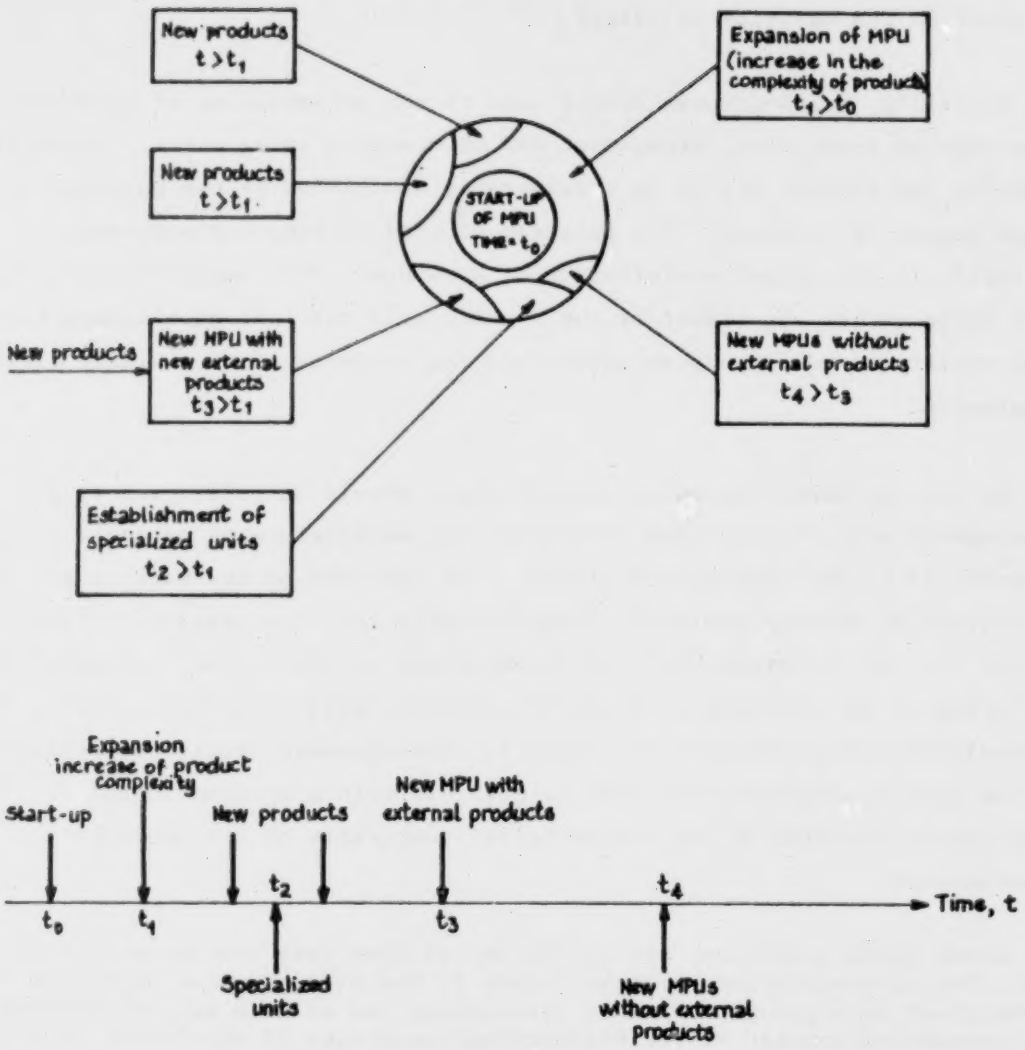

Figure 2: The dynamics of multi-purpose units over time

43. From this point of view, it will then be possible to achieve precise and interesting goals for the developing countries, namely:

- Specific and precise guidelines for the establishment of new multi-purpose activities in existing engineering industries;

- Precise guidelines to rehabilitate and expand the enterprises that are already operational;

- A correct overview in cases when it is necessary to study and promote several multi-purpose plants as part of an industrialization plan (see ongoing UNIDO project in Tunisia);

- A thorough approach when it is desired to make diagnoses of multi-purpose enterprises and to correct any operational defects.

Agricultural machinery and multi-purpose units

44. Agricultural machinery is not a special case but rather represents one of several possible types of final and intermediate capital goods that can be produced by the multi-purpose approach. Therefore, the discussion of the preceeding paragraphs applies here too.